WHAT IS THE BEST METHOD OF TEACHING MICROSCOPICAL SCIENCE IN MEDICAL SCHOOLS?

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During the last decade, few questions in medical sociology have attracted greater attention than medical education. The requirements of our colleges not being equal with those of other countries, nor with other departments of education in this country, it was but natural that the profession, as a whole, the medical press and societies should join in a demand for needed reforms. My apology is due to you for bringing this subject before you in a necessarily imperfect way; but I hope for a discussion of ideas, and to learn other ways and means, rather than to give much of value.

By microscopical science, the scope of this paper includes those subjects taught in medical colleges wherein the microscope plays an important part. We shall consider:

(*a*). How much time should we devote to these subjects, out of a four years' course of nine months each, including holidays and examinations?

(*b*). In what years can the subjects most profitably be placed?

(*c*). By what methods should each of these subjects be presented to the students?

1. Lectures and recitations.
2. Laboratory work.

(*d*). What are the best modes of testing or giving credit for work done in each branch?

(*a*). In arranging a medical curriculum, it is a matter of great difficulty to divide the time fairly among the several subjects, giving each its due amount in proportion to its

importance. In far too many medical schools, a proper *balance* is not preserved, one subject being allowed to usurp time really belonging to another, to the great detriment of the student. This is especially prone to occur where there is a considerable difference in the teaching power of the professors of the respective chairs.

Not long ago the committee of the Association of American Medical Colleges, devoted to bacteriology twenty-five lecture hours and 150 laboratory hours, a total of 175 hours, while in pathology, fifty hours of lecture attendance and 100 hours of laboratory work were deemed sufficient—less by twenty-five hours than the time required for one of its subdivisions! Some colleges prefer to give only two hours a day to laboratory work and one to lecture. In such work as bacteriology this seems to me unfortunate, especially when the hours are arranged with an interval either too long or too short. Many students lose the value of their cultures through long waiting, or the growths have time to become contaminated.

(*b*). As regards the placing of the several subjects much difference of opinion exists. Histology with embryology usually comes in the first year. It may be questioned whether it would not be much better to put embryology in the first half of the second year, when some knowledge of osteology, elementary anatomy, physiology and histology has been taught. Many colleges place bacteriology in the first year. This is to be strongly condemned, I think, because bacteriology requires a great deal of dexterity in handling tools and instruments, including oil-immersion lenses, and also a fair knowledge of physiologic and organic chemistry, and some acquaintance with diseases. I am here referring to a complete course, and not to the mere elementary outlines and details so often taught. The proper place seems to me to be in the second half of the second year, after the chemical course is finished, when we have had some elementary general pathology, when the question of saprophytic bacterial poisons can be better understood. The formation

of sepsin and its resultant irritative action on the tissues plays an important part in the study of inflammation ; and the infective circulatory diseases certainly can be better appreciated after an acquaintance with bacteriology. The same is true of the infective granulomata. What can we intelligently teach of tuberculosis or leprosy if we know nothing of the bacilli occurring in the same, and their effects ? Without any doubt, bacteriology should go hand in hand with pathology, or closely following it, and both should have been preceded by some practical laboratory work in histology and elementary biology. Indeed, we have no business to teach pathology to students who have not completed theoretical and practical histology, as is now so often done, especially in colleges that accept the B. A. degree as an equivalent of one year's work. Only a science, and *never* a classic degree should be accepted as such equivalent, and it should include Latin or Greek, German and French as well as technical work, which I believe at the present time it does in most universities. No student can study pathology profitably without first knowing his histology, and such an attempt should be forbidden by the Faculty of the school. Unfortunately the rule too often stands "each man for himself," each professor knowing and caring but little of any chair but his own, and the student certainly not the wisest judge of the order of his studies. I enter an emphatic protest against the faulty grading of students. One who is allowed to begin work in a course for which he is not prepared is a hindrance to the demonstrator, a detriment to the whole class, and besides, he is seriously wronged himself, since he cannot understand what he is trying to learn. The only resource for him is a special tutor.

How then shall we arrange the teaching to obtain the necessary practical results for a medical student in a limited time, with limited apparatus and demonstrators ?

If the first year is divided into first and second semesters, let the class begin anatomy and general biology, as outlined in Parker's or Campbell's elementary biology, or in Huxley

and Martin's. Then follow with the dissection of a cat or dog, using Howell's Dissection Manual. The frog is rather small for beginners, but those who prefer it can work easily from Marshall's little book, or McAlpine's Zoological Atlas. Martin and Moale, Vol. III., is a good guide to the dissection of a rat. The particular animal and text-book selected is of minor importance. Any one of them, carefully worked through, will fix the main anatomical and osteological facts, and give the requisite manual dexterity for later work on the human body. Nothing is more absurd than to place raw medical recruits beside a cadaver, after reciting a few lessons from a book, and expect them to dissect half a human subject in six or eight weeks, working two hours a day. Much better, more intelligent work can be done after the general preliminary training advised above. Elementary chemistry can well be taught at the same time. Indeed, the repetition of terms in the different classes, the explanations given and positions indicated, all amount to a practical translation of the Latin terms in osteology, myology and so forth, and serve to fix in the Freshman's mind what otherwise would be lost.

Embryology is best done in the spring months, when eggs can be easily obtained. In the meantime, histology is occupying some six hours a week, four in laboratory and two in lectures and recitations. Here we are increasing our dexterity and learning the application of anatomy and physiology, and their intimate relations with each other and with chemistry. In the histological laboratory, what shall we teach the student ? First, an intelligent *use of the microscope*, its construction and optics. Then methods of hardening, cutting and staining sections, each member of the class, in turn, being instructed to cut sections with the freezing microtome and bottle and label for the class use, so that there are always plenty on hand for testing any desired staining method. And finally, a systematic study of the histologic structure of the tissues and organs of the human body.

In bacteriology, no single text-book fulfills all requirements. Abbott is very useful, but personally, I think, for a first book, Kanthack and Drysdale's little work is most excellent ; for if a student be given a culture, all details are practically laid out for him, to the great economy of the demonstrator's time, the book being on the plan of the old standard and excellent form in Huxley and Martin's biology.

The student in bacteriology must be taught to make clean, well-stained preparations of some organism, with exactness, so that every *bacterium* is sharply seen when examined. The poor, hazy, half-stained and often milky smears allowed are too commonly found in students' hands and reflect no credit on teacher or pupils. In addition to making neat, accurate mounts, the preparation of media and making inoculations show the student *how to work*—which is far the most important—namely, in a clean, orderly, concise manner. Elaborate methods and appliances should be avoided as far as possible, so that the student can soon learn what is essential and how he can best obtain or make things for himself, after he goes out from the laboratory. Assign to one student a given subject, and require a complete examination and report. Teach him how to proceed to make an original investigation, what are the necessary steps to follow, how to isolate and obtain his own pure cultures from raw material. When he can do these accurately, he can safely be said to know the main processes and principles, at least, in making a bacterial investigation, no matter where he is situated. And this is precisely wherein, I think, our graduates of medicine are lacking. Few of them are able, after leaving college, to proceed to make a complete investigation, on their own resources. Their knowledge of classification, experimental inoculation and subsequent recovery are too vague to be trusted, even by themselves. It is not right to urge that all laboratory work should be out of the way by the end of the second year, as many colleges do, by requiring junior and senior students to spend all their spare time at clinics, forbidding them to take laboratory courses during the third and

fourth years. It is a fact that students are very prone to get their earlier work hidden away in deep recesses, and to forget how to do things they formerly did well; and it is easy to understand how a student who "finished" his general pathology and bacteriology in the second year may not be able to apply them to his practical medicine and surgery.

General pathology should commence in the second year, and from the first it should be the aim of the instructor to show the deviations from the normal by comparison, and by demonstration of actual specimens, under supervision of the lecturer, who has arranged typical places in the field, and has illustrated them by the lantern. In this course, celloidin and paraffin cutting can be given, as well as special modes of staining, particularly each of the special reactions, as amyloid, and the like. Double staining can here be practised to advantage, and the specimens can be then studied and drawn. Personally I think drawing is best left out after the biologic and histologic courses, because it takes a great deal of time which the student can ill afford to spare. Do not infer that I wish to depreciate this important subject. In science courses, it should certainly hold a strong place. But in medical schools the time is too short, and many of the students have to do outside work to pay their way through college. For the majority of our classes, utility alone is to be considered.

Of far greater value than the ability to draw well, is the practical application of the knowledge required. Pathology, in its truest and fullest sense is to be defined as the theory and science of medicine, to the understanding of which normal structure and function are necessary. True, it is impossible to teach all medical science from the chair of pathology, but the pathologist should maintain clearly the relation which disease bears to the normal bodily condition. He must detail, as completely as the state of science permits, the altered modes of function of diseased organs, the external manifestations of these altered functions, and their remote and direct effects upon the economy. The habit of teaching

pathology as a bare mass of facts with no relative bearings upon physiology, clinical medicine and therapeutics or surgery is much to be deplored. It is no wonder students so taught regard mounts as an everlasting bugbear and nuisance.

The study of medicine comprises three well-known groups of subjects :

(*a*). Preliminary studies—anatomy, physiology and chemistry.

(*b*). Developmental—those branches which teach the causes of disease, and the altered functions met in disease—that is, pathology.

(*c*). The application of these studies to the recognition and treatment of disease—that is practice and surgery. This shows us that pathology is an intermediate subject between biology and practice. As certainly as the gun-shot wound, the tubercular joint, the fractured bone, or the cancer of the liver take their places in the pathological museum, so should the altered function be regarded as a pathologic study. The man who recalls from his book that renal or cardiac disease may often present, as a symptom, dropsy, is far more liable to miss entirely the vital point in his examination for a diagnosis than the man who has been taught to regard dropsy merely as a manifestation of a circulatory fault, and who has been trained to seek carefully for the arterial disease, or for the cause of venous or lymphatic insufficiency along the courses of these currents whenever examination is possible. The failure to acquire habits of pathologic reasoning, of comparing the diseased structure to the normal, the diseased function with the normal function, of seeking for etiologic influences within as well as without the body is often never overcome. The sneering remark that the pathologist only makes a post mortem diagnosis, has too much truth to be overlooked. This overweening influence of the importance of pathologic anatomy, the confused pathologic histology and microscopy, as applied to medicine, has been the cause of the great impetus given the anatomic school of

pathology by the great Virchow and through it our advance in this line of work has come. There is a pathology beyond this, however, and for the general practitioner our schools ought to make every effort not to turn out specialists, but careful, conscientious, scientifically educated, practical physicians, with the further privilege of study for higher or future specialistic work if they so desire. For convenience let us divide pathology into three well marked schools:

I. Anatomic pathology, of which the learned Virchow, Ziegler, Klebs and Gross are the best exponents.

II. An etiologic school, at whose head stands Koch and Sternberg, the bacteriologists.

III. A physiologic is, but unfortunately, the least developed, but the most applicable without any doubt to the wants of the busy practitioner of medicine, for example Von Jaksch and Vierord and Osler.

The first was created by the doctrines of cellular pathology of Virchow and has since advanced by the increased facilities of observation.

The second was made possible by the perfection of the microscope and its appliances through the energy of Zeiss, Tolles and by the apparent exhaustion of results of our anatomic study of diseased tissues. Observations naturally drifted towards examination in the existence and nature of parasitic microörganisms and the brilliant successes of this second school, the etiologic, have caused bacteriology to almost outgrow its relative importance in the study and teaching of pathology and almost, if not quite, occupy as high or a higher position. While the third, the pathologic physiologic, has been limited and failing to attract notice by experimental work and popularity, because of the difficulty of demonstration and proof of its principles and details, has had little or no growth and so far has received from teachers of pathology not half the attention its practical value demands. It is this division which makes a man an intelligent practitioner and the ignorance of which makes of him the routine follower of other men's methods.

No one science should be taught to the exclusion of the other and especially is this so of bacteriology. It is proper to teach the nature of microörganisms which are causative, say of ulcerative endocarditis, that we instruct as to the gross and microscopic changes eventually made in the affected valve when the acute stage is over, but at least remind him of how these changes make known their presence, why they must finally end in cardiac hypertrophy and degeneration, and further how these subsequent alterations indicate their presence, and why such abnormalities in the heart must result in vascular changes, in lungs, liver, spleen, kidneys and so forth, and how he may estimate somewhat the rate of progression and what termination he may expect. Just as we know therapeutics must always belong to the order of applied sciences, and will bear the same relation to pathology in an extended sense as does engineering to mathematics, therefore, as engineering is applied mathematics so therapeutics will be applied physiology and pathology.

One of the most important obstacles to real progress in scientific development and accuracy, is the want of perseverance on carefully devised plans for insuring completeness of investigation before announcing results. Much of our scientific and experimental work is done in fragments and necessarily results in the development of isolated facts and partial views, filling the pages of literature with everchanging and often contradictory inductions. Another obstacle, and a serious one, lies in the frequent formulation of inductions, or more properly assumptions for practical guidance, founded on an inadequate number of facts, and sometimes on mere analogies. Still a third obstacle is the constant tendency to concentration of all attention on the results of any new line of investigation started to the neglect or rejection of facts and inductions previously well established and the verification by abundant clinical observation. From this it will be seen special pathology is assigned for the junior, or better, the senior year, when the associated studies—medicine, autopsies and bacteriology—are well in hand and more profit

gained by their co-relations, leaving clinical microscopy for the terminal part of the senior pathology, when students have access to the wards and can thus intelligently utilise the material and at the same time increase his laboratory knowledge. In closing, the question of examination of students is still much discussed, for the lecture is not sufficient and has many objections. The recitation method is only applicable to small classes, and for some students who are of a nervous temperament are not a fair test. The writing and correction method is excellent but not sufficient. Unless we can insure honest work, it is a severe tax on the teacher who corrects the papers and with slow writers does not give them a chance. It is a good plan to have a debate-day to teach the value and use of books and journals and so encourage a wider field of reading and consequent discussion, as well as to elicit many practical questions on not only the subject in hand, but its subdivisions and thus aid in showing a student the subject has a practical value and an intimate bearing with the sciences, most of which embrace the microscope. This, it seems to me, is the best method of teaching micro-science in medical schools.

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